The state of Australia's avifauna: a personal opinion and prediction for the new millennium

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ABSTRACT

A consequence of the European colonization of Australia has been a significant loss of biodiversity: one in four mammal species is either extinct or threatened. In contrast, only one species of bird has been lost from the Australian continent and there is less concern for the survival of the Australian avifauna than for mammals. This is despite the fact that nearly one in five bird species is listed as threatened or of "special concern". Moreover, a review of the status of Australian birds at local, regional, state and continental scales shows that the impact of Europeans on the avifauna is much greater than acknowledged. Over most of southern Australia entire avifaunas are threatened with extinction. When allowance is made for habitat loss and degradation, 30 to 90% of bird species across the continent have declined in abundance. The extent of this decline is that the survival of many bird species in the 21st Century is threatened. While a majority of birds in southern Australia has declined in abundance and/or distribution, others have increased. Parallel changes are proceeding in northern Australia. In terms of evaluating impact on the avifauna, an increase in numbers and a change in the composition of avian communities are as significant as the loss of populations and species. Both adversely affect patterns of continental biodiversity and are ecologically dysfunctional.

Assuming that current trends continue, over the next century, significant components of the avifauna will be lost as populations proceed to extinction and the composition of avifaunas change at scales ranging from the local to the continental. The pattern of change in avian abundances, and the failure to anticipate or acknowledge the major losses of birds on the Australian continent, shows that conservation emphasis needs to shift from a species by species approach to the conservation of communities and entire avifaunas. Taken together, the scale of the changes in the distribution and abundance of Australian birds is an affirmation that present and projected patterns of human use of the Australian continent are not sustainable. Much needs to be done to reverse the decline of the terrestrial avifauna and achieve ecological sustainability in land use. The most urgent actions are to end the clearing of native vegetation, reduce grazing pressure, remove inappropriate fire regimes, control feral and native animals whose abundance threatens native species, and restore functional ecosystems, with an emphasis on native vegetation, to a minimum of 30% of the landscape. These need to be accompanied by an aggressive programme to improve water quality in fresh water habitats and restore environmental water flows, and the creation of a comprehensive, adequate and representative reserve system across the continent irrespective of land tenure. In the absence of such action, I predict that Australia will lose half of its terrestrial bird species in the next century.

Key words: Australia, Birds, Extinction, Conservation, Environment, Threated species.

INTRODUCTION

When Recher and Lim (1990) reviewed the impact of European colonization on the vertebrate fauna of Australia, they found that the greatest changes in abundance, accompanied by a high level of extinctions, had been documented among mammals: one in four mammal species is either extinct or threatened as a result of European settlement. A consequence of the severity of the impact on mammals, and the interest in this group of animals among Australian biologists, was an attitude that birds were abundant, widely distributed and secure (Recher and Lim 1990). In the past decade, there have been encouraging signs that this view is changing (e.g., Woinarski and Braithwaite 1990; Garnett 1992; Robinson 1993; Saunders and Ingram 1995; Robinson and Traill 1996; State of the Environment Advisory Committee (SEAC) 1996; Lunney *et al.* 1996, 1997; Craig 1997; Stattersfield 1998; Franklin, in press).

Despite changing perceptions, in my opinion, the impact of Europeans on the Australian avifauna continues to be underestimated by all but a few biologists, and far from being secure, birds have been as adversely affected as mammals, albeit with few extinctions. Recher and Lim (1990) predicted that, without changes in land management (see Newsome 1994), there would be further significant declines in the distribution and abundance of birds in the same parts of Australia where mammals had already disappeared; a view echoed by Woinarski and Braithwaite (1990) in their evaluation of the distribution of Australia's endangered fauna and by Lunney *et al.* (1996, 1997) in their assessment of the endangered fauna of New South Wales. According to Recher and Lim (1990), major losses of bird species would occur first in the agricultural and pastoral regions of southern Australia, but similar losses would develop in northern Australia as development, agriculture, land degradation, and the human population of the north expanded. An important factor affecting the decline of birds in Australia is the change from Aboriginal land management practices, in particular, Aboriginal use of fire to manage native vegetation, to European management regimes and consequent changes in the extent, intensity and frequency of fire (see Woinarski and Recher 1997 for a review of the effects of fire on the Australian avifauna). The impact of these changes is perhaps most noticeable in northern Australia where the changes have been most recent, European development is less intensive, and the human population sparse (see Franklin, in press).

In this paper, I discuss the decline of the terrestrial avifauna of Australia and demonstrate that there have been major losses of birds which have impoverished large areas of the continent. I also note that a small number of species have greatly increased in distribution and abundance. In my opinion, such increases are as symptomatic of adverse impacts on a biota as are declines in abundance or extinctions.

My assessment of the status of Australian birds is based on the literature, on discussions with biologists throughout Australia, and on my own observations of trends in avian abundance since the mid-1960s. I assess status by emphasizing changes in the composition and species abundances of local and regional avifaunas. Of growing importance here is the value of ecological history, where the pattern is emerging that the losses of Australian biodiversity were greater, and occurred earlier, than is generally recognized (e.g., Lunney 1994, and see Ashby 1924 and Barnard 1925). Taking a historical perspective, I again predict the loss of significant components of the Australian avifauna during the 21st Century, while a few species will continue to increase in numbers.

RATIONALE

Since the introduction of threatened species lists, considerable effort has been made to reduce the level of subjectivity and develop objective and numerical criteria for the listing of species (e.g., Mace and Lande 1991; Collar *et al.* 1994; Mace and Stuart 1994). Mace and Lande (1991) in their evaluation of the system used by the IUCN in assigning species to categories in the Red Data Books attempted to quantify levels of risk in terms of the probability of extinction within a specified period of time. Extinction probabilities were quantified by population size (of the species), the extent to which populations were fragmented (number and size), rates of immigration, and declines or fluctuations in population size within specified periods of time. An element of subjectivity was retained by considering "observed, inferred or projected" threats of habitat alteration, exploitation or interactions with other species that might affect species survival (Mace and Lande 1991; Mace and Stuart 1994). However, proposals to quantify and simplify the largely subjective assessments of the status of taxa listed in the first Red Data Books continue to emphasize the extinction of species, but the number of categories to which species can be assigned has been increased based on perceived probabilities of extinction at intervals of 10, 20 and 100 years (Collar *et al.* 1994; Stattersfield 1998). Although determining the status of populations is part of deciding a species' status, emphasis effectively remains on the extent to which a species, as distinct from its separate populations, is threatened (however, see Ryder 1986; Moritz 1994; Mayden and Wood 1995; Pennock and Dimmick 1997).

Reducing subjectivity increases the value and reliability of threatened species lists (Crosby *et al.* 1994) and improves the credibility of models predicting the loss of significant numbers of species within ecological time. Nonetheless, in any system where the emphasis is on the extent or degree to which a taxon is threatened with almost immediate extinction, there is the risk that taxa which do not meet the criteria will not be considered threatened or in "no reasonable risk of extinction" when in fact they are endangered. This may occur even though a taxon has experienced significant decreases in abundance and distribution. For example, abundant species (e.g., >10 000 pairs) which otherwise met the criteria of Mace and Lande (1991), would not have been perceived as threatened. Current criteria for endangerment avoid some of these problems by considering abundance and rates of decline separately (Collar *et al.* 1994; Tucker and Heath 1994; Stattersfield 1998; Garnett 1999). Thus, in current assessments, abundant species which have experienced rapid rates of decline can qualify as threatened.

The approach I take in evaluating the status of the Australian avifauna emphasizes declines in abundance at any scale (local, regional or continental) and considers species in the context of the avifaunas within which they occur. I try to avoid a species by species assessment. To some extent this approach is forced by the lack of quantitative information on the abundances of Australian birds. Even if quantitative data were available, declines in abundance and regional extinctions (i.e., loss of populations) based on long-term observational data (i.e., non-quantitative observations) and/or deduced from the historical record, along with changes in the species composition of communities, tell us more about the status of the avifauna than the extinction of a species. Even in the absence of quantitative or observational data, changes in avian abundance and species composition can be deduced from the known pattern of land use and changes to the vegetation (e.g., Lunney 1994), but is an approach little used in Australia.

I argue that regional changes in abundance occur in proportion to the loss and degradation of habitat and that habitat loss and degradation need to be given greater weight when evaluating status than has been the case. By degradation I mean any change in the environment which adversely affects ecosystem functions and processes: among many others, soil erosion, proliferation of weeds and feral animals, changed fire regimes and loss of biodiversity are simultaneously symptoms and causes of degradation. Moreover, the status of a species changes whenever it decreases or increases in abundance and either may occur with the loss and degradation of habitats. In my opinion, insufficient weight is given to increases in abundance when evaluating the status of the Australian biota. Yet, human induced increases in the abundance of species are as clear an indication of environmental disruption as the decline and extinction of species. For example, in a review of the impact of artificial sources of water on the biota of the arid and semi-arid zones of Australia, James *et al.* (in press) point out that "... the increase in abundance of a species may have significant negative effects on other species." Of the 92 species of terrestrial birds identified as affected by the provision of artificial sources of water, half increased in abundance while half decreased (James *et al.*, in press). Obviously, it would be misleading to only identify the species which declined when evaluating the impact of providing artificial sources of water.

I interpret status as the long-term prospect of a species and/or the avifauna continuing to contribute to ecosystem functions and processes. A species which increases in numbers negatively affects other species and disrupts ecological processes thereby adversely affecting ecosystem function. As in the study of James *et al.* (in press), an evaluation of the status of the avifauna must therefore consider increases in numbers as well the decline and loss of species.

Moreover, a species may lose its ecological significance, in an ecosystem or community sense, long before it becomes extinct. Extinction is therefore a final event and is not necessarily the most important outcome of a species' decline. My overriding assumption is that, without changes in community attitudes to land management, current trends in habitat loss and degradation will continue (see Glanzig 1995; Graetz *et al.* 1995; SEAC 1996 for details on habitat loss and degradation in Australia) and that trends in the abundances of birds will parallel these. Thus, my interpretation of the status of the Australian avifauna is more ecological in the sense of being population and functionally based, and less legalistic than, for example, the assessments of Garnett (1992) and Lunney *et al.* (1996) who emphasized species and total numbers to fulfil policy and legislative criteria. While the survival of individual species is important, of greater importance is the retention of the evolutionary potential of the avifauna and the contribution of birds to ecological processes. Thus, returning to my earlier comment that "extinction is a final event", my emphasis is on populations and communities. Moreover, a species may remain extraordinarily abundant, and therefore its status will not be evaluated, when in fact it is in decline and threatened. As numerous historical examples attest, abundance by itself does not mean a species is not at risk of extinction or that it is functional in an evolutionary and ecological sense.

If a species remains abundant or widely distributed, how can it be considered as threatened? There are several possibilities independent of total numbers. First, isolation into multiple smaller populations increases the probability of extinction of each isolate with decreased chance of recolonization. As populations become extinct, the risk of extinction of the species increases. Second, fragmented populations, especially if restricted to the margins of the species' original distribution, may have reduced evolutionary capacity (e.g., reduced genetic heterozygosity and gene flow) to respond to long-term environmental change. Third, it is not known how important exchange of individuals throughout the original distribution is in maintaining population viability. For example, if a species maintained its distribution through centrifugal dispersion (from the centre of its range out), or from one part of its distribution to another, then the risk of progressive and accelerating decline and extinction is high whenever that pattern is disrupted. Fourth, internal fragmentation of vegetation remnants may also be significant with the actual area of habitat for each species being smaller than the remnant as a whole (e.g., Arnold and Weeldenburg 1998). Populations which appear to have an adequate area reserved for their survival may in fact be confined to areas of marginal extent or habitat quality. Given the risks of periodic drought and the contraction of the area of suitable habitat for all species, the spatial constraints of small areas and isolation place even multiple, large populations at risk of precipitous decline and extinction. This is a point made eloquently by Morton (1990) in his analysis of the impact of European settlement on vertebrates in arid Australia.

When considering the status of an avifauna, consideration must therefore be given to threatening processes, such as habitat loss and changed fire regimes, and chance climatic events, acting in synergy. Also, it is important to recognize that the impact of environmental change can be independent of total population size. Finally, John Woinarski (*in litt.*) has pointed out that the loss of populations may signify the vulnerability of the species as a whole to environmental change. I would add to this that the loss and decline of species' populations may signify the vulnerability of particular taxa (e.g., families), guilds (e.g., ground-foraging birds) or even entire avifaunas (e.g., woodland birds) to environmental change.

None of the above is intended to suggest or imply that there should not be a formal system, with legislated responsibilities, to identify and list threatened species or ecosystems and the processes by which they are threatened. However, we need to recognize the limits of such systems and be prepared to respond to changes in the abundance and distribution of species and the composition and structure of ecosystems even though the changes may not qualify the species or systems concerned as formally threatened. Because we will probably always lack critical information on the status of most species and because our cultural biases focuses our attention on only a small number of particularly charismatic, conspicuous or easily identified species, the majority of species, irregardless of threats to their survival, will never be "officially" recognized as threatened. It is my thesis in this paper that most Australian birds (taxa and populations) fall into this category: small, brown and not noticed (especially when extinct). It is also important to understand that concentrating conservation efforts on species only after they have been listed as threatened is not necessarily the best use of limited conservation resources. The inevitable consequences of such an approach are that we react to changes after it is largely too late, instead of anticipating changes when we still have time to succeed.

STATE OF THE AUSTRALIAN AVIFAUNA

Garnett (1992) used the criteria of Mace and Lande (1991) to evaluate the status of threatened and extinct birds in Australia. Of the 941 taxa occurring on Tasmania and mainland Australia, he considered 100 (10.6%) as threatened, and 71 (7.5%) as taxa of special concern; a total of 18% of the continental avifauna. This did not signify that the other 82% of taxa were secure and not threatened. Garnett (1992) was required to operate within specified limits as defined by the criteria of Mace and Lande (1991), as well as the legislative and policy requirements of government. In the absence of quantitative data for most of the continent, a conservative assessment of status was inevitable. By stepping outside these constraints, as outlined above, it is possible to reach different conclusions about the state of the Australian avifauna.

Historical trends

Garnett's (1992) analysis is the most comprehensive and recent available for the Australian avifauna and it is instructive to compare his assessment to earlier lists. As recently as 1996, the IUCN listed only 44 taxa of Australian birds as threatened (IUCN 1996). In 1991, the Australian and New Zealand Environment and Conservation Committee listed 72 taxa as threatened. In his review of Australia's endangered species, Kennedy (1990) listed 103 avian taxa as threatened, with three taxa probably extinct and 22 endangered. In 1988, the Committee of Nature Conservation Ministers considered 33 taxa of birds to be endangered. In 1983, the Total Environment Centre (TEC) (1983) identified 69 Australian taxa as vulnerable to extinction. Earlier, the Red Data Book (ICBP 1981) listed 14 Australian avian taxa as endangered. Thus, there has been a progressive, if erratic, increase in the number of taxa listed as threatened.

The increase in the number of taxa listed as threatened since 1980 is the result of more information, clearer definitions, and a better understanding of extinction processes rather than the result of sudden declines in species abundances. This shows that the number of threatened birds in Australia has been consistently underestimated and that the information base is inadequate for purely objective assessments. Dan Lunney (*in litt.*)

points out that, because the number of listed taxa is still rising, the number of threatened birds remains greater than officially recognized. Only when it plateaus can we be confident that the number of threatened taxa listed approximates the real number.

Indicative of the paucity of information and the likelihood that the threats to the Australian avifauna are underestimated is the emphasis in all the published lists of threatened species on large, colourful, conspicuous, and charismatic species (e.g., parrots, seabirds, pigeons, wrens, and owls). Most lists are dominated by non-passerines. These are the groups with the best knowledge base (see Lunney *et al.* 1996). Yet when regional avifaunas are studied (e.g., the Western Australian wheatbelt) many more passerine species have declined than non-passerines (Denis Saunders, *in litt.*). The lists also under-represent ecological categories, such as ground-foraging and nesting birds, and woodland species, known to be in decline throughout Australia (see Garnett 1992; Robinson 1993; Saunders and Ingram 1995; Robinson and Traill 1996; Lunney *et al.* 1997).

Distribution of threatened birds

Woinarski and Braithwaite (1990) and Garnett (1992) analysed the distribution of threatened birds on the Australian mainland and Tasmania. The greatest number of threatened taxa occurred along the coastal fringe with the highest concentrations in the south-east (including Tasmania), east, north-east, far north, and southwestern parts of the continent. This coincides with the distribution of species-rich forests and woodlands (Pianka and Schall 1981). According to these analyses, relatively few threatened taxa occur in the arid and semi-arid shrublands and grasslands of the interior. However, these areas have had few studies and the apparent lack of change is more likely the lack of data than an indication that arid and semi-arid avifaunas have been little affected by Europeans (Saunders and Curry 1990).

Analyses of the status of terrestrial birds on a continental scale conceal changes in the distribution and abundance of the Australian avifauna that have occurred on a local, regional or state level. Regional assessments are useful for the prediction of long-term trends in abundance and may provide a more accurate assessment of the status of the continental avifauna than continent-wide assessments. Among the reasons for this are that there are more long-term data for small areas and regions than for the continent as a whole. Long-term data are necessary to pick up trends and identify changes in abundance. Moreover, local losses may not be apparent in a continental assessment until there are so many losses that the situation is irretrievable. The same may also be true for increases in abundance.

It is also important to take a historical perspective. Often species were lost from an area or region long before records were kept and remarkably rich, modern avifaunas may already have experienced significant changes in abundance and species composition (e.g., Recher and Serventy 1991 and Recher 1997a for Kings Park, Perth, Western Australia).

Regional assessments

State avifaunas

Garnett (1992) reviewed the status of the avifauna in each of the States and Territories of Australia. South Australia had the greatest number of threatened taxa (115), while Tasmania (27) and the Northern Territory (22) had the fewest. New South Wales had experienced the greatest number of extinctions (12), while only one species was considered extinct within Queensland. The number of extinctions and threatened taxa listed by Garnett (1992) for the States and Territories reflect the differences between the States and Territories in land area, number of taxa, differences in land use over time, and the level of knowledge of each avifauna. Information is probably poorest for Queensland and the Northern Territory, but better, although still incomplete, in other, more densely populated jurisdictions.

In addition to Garnett's (1992) report, state-wide assessments of the avifauna are available only for Victoria and New South Wales, with a less detailed account for Queensland.

Forty terrestrial bird species were listed as threatened in Victoria by Baker-Gabb (1990, in Robinson 1991). A further 191 terrestrial species were considered common and not threatened (Robinson 1991, *in litt.*). However, Robinson (*in litt.*) found that 71 of these 191 species had either experienced local extinction (15 species) or had declined in abundance throughout the State (56 species). Thus, using the criteria of endangerment which weight declines in abundance (and local extinctions) equally with overall numbers, of 231 terrestrial bird species in Victoria, 101 (44% of the terrestrial avifauna) are threatened. Garnett (1992) listed 58 (25%) Victorian taxa as threatened.

The 1974 Schedule 12 of the NSW National Parks and Wildlife Act listed 92 birds as threatened in that State. This included

38 Palaearctic waders protected by international agreement (therefore not necessarily threatened) and species not found in New South Wales, but listed as threatened in other states. Excluding Palaearctic waders and birds not found in the state, only 36 of the 92 taxa occurred or formerly occurred in New South Wales. Ten of the 36 were considered threatened and five were listed as in imminent danger of extinction or were already extinct in the state.

Additional information and a more critical assessment of status substantially increased the number of avian taxa in New South Wales listed as threatened. Based on a survey of biologists familiar with the State's avifauna (Lunney *et al.* 1996), 110 (23%) of the 473 bird species, including seabirds and Palaearctic migrants, occurring in New South Wales were listed in 1992 as endangered under the NSW *National Parks and Wildlife Act 1974*, as amended by the *Endangered Fauna (Interim Protection) Act 1991*. This list was transferred unchanged to its replacement, the *Threatened Species Conservation Act 1995*. Twelve species are extinct within the state. Thirty-two taxa are listed as endangered and 78 as vulnerable[1]. Among terrestrial birds, 68 (22%) of 315 taxa are considered threatened (data from Lunney *et al.* 1996, Table 5). Garnett (1992) listed 91 taxa in New South Wales as threatened. Garnett (1992) included taxa from Lord Howe Island which were also included in the assessment of Lunney *et al.* (1996) as subspecies, their only departure from using species.

Comben (1993) relied on the list of threatened birds of Australia (Brouwer and Garnett 1990) to quantify the number of threatened bird species in Queensland. He concluded that 28 of the 52 listed taxa occurred in Queensland. This is about 5% of the 540 species regularly occurring in the state. None of the other contributors to Catterall *et al.* (1993) assessed the avifauna of the state as a whole, although Woinarski (1993) listed the threatened birds of tropical savannahs. Garnett (1992) listed 51 taxa in Queensland as threatened.

It is evident that there are significant differences across Australia in the assessment of State avifaunas. Reasons for this arise partly from different levels of research on birds, but there are also considerable differences across Australia in legislation regarding threatened fauna. In the absence of endangered species legislation, as for example in Western Australia and Tasmania, there is not the same compulsion as in New South Wales for State fauna conservation authorities to comprehensively assess the status of birds or other biota. Nonetheless, there is the inescapable conclusion that the impact of European settlement on the avifauna has been greatest in the most populous southern and eastern states where broad area agricultural development and land clearing has occurred, and land degradation is extensive (SEAC 1996). As predicted by Recher and Lim (1990), the impact on the avifauna will extend west and north across Australia as development and land clearing proceeds and agriculture intensifies.

Regional studies

European settlement of Australia was accompanied by pronounced and rapid changes in the abundances of native mammals. Often there was a brief period of increase as habitats were modified and forests opened for agriculture, followed by rapid extinction (Jarman and Johnson 1977; Lunney and Leary 1988; Recher *et al.* 1993; Lunney *et al.* 1994). Recher and Lim (1990) found no reports of a similar pattern of increase and decline among birds. Instead, the pattern they reported was one of regional decline, often with local extinction, of most species accompanied by the increase in abundance of a few others. In my review of the literature reported here, I can find no evidence to the contrary, but it is an issue which should remain open to research. In the following, I summarize the available regional studies and for some I contrast my assessment of the status of the regional avifauna to that given by the authors.

Western Australian Wheatbelt

Kitchener *et al.* (1982) and Smith (1987) suggested that no species of bird had been lost from the Western Australian wheatbelt. However, many species had declined in abundance and were restricted to remnant native vegetation. In contrast, Saunders (1989) reported a rapid loss of species from wheatbelt reserves accompanying broad area clearing of native vegetation from the 1930s through the 1960s.

In what is the most comprehensive study of a regional avifauna, and based on 187 observers collecting data between 1987 and 1990 and comparing it with historic records from 1900 to 1937, Saunders and Ingram (1995) presented data on the distribution and abundance of 195 species of wheatbelt birds; 108 non-passerines and 87 passerines.

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[1] Unfortunately, the *Endangered Fauna (Interim Protection) Act 1991* reversed the use of 'endangered' and 'threatened' relative to national and international usage. This error was corrected in the *Threatened Species Conservation Act 1995*. Here I use the words according to the IUCN definitions.

Of these, 37 (34%) non-passerines and 58 (67%) passerines have declined in distribution and/or abundance (Saunders and Ingram 1995). Twenty-one species (19%) of non-passerines and 13 (15%) passerines have increased in abundance and/or distribution. Considering only terrestrial birds and excluding vagrants, 29 (49%) of 59 non-passerines have declined in abundance and/or distribution, 12 (20%) (including three exotic species) have increased, while the remainder are unchanged (data from Table 1 in Saunders and Ingram 1995). Overall, the impact has been greatest on resident terrestrial species (Saunders and Ingram 1995). Fifty (72%) of 69 resident passerine species have declined, while 12 (17%) have increased (Saunders and Ingram 1995). Of 43 species of resident terrestrial non-passerines, 22 (51%) declined and 12 (28%) (including three exotics) increased (data from Table 1 in Saunders and Ingram 1995). According to Saunders and Ingram (1995), the impacts of habitat change and loss in the wheatbelt were greatest on resident birds dependent on native vegetation: of 33 species of dependent non-passerines and 68 species of dependent passerines, 24 (73%) and 49 (72%), respectively, declined (data from Table 3 in Saunders and Ingram 1995).

The impact of European settlement has been greatest in the parts of the wheatbelt where clearing has been most extensive. In the central wheatbelt, more than 90% of native vegetation has been cleared and remnant vegetation is degraded and/or occurs in small, isolated patches (<100 ha in area) (Saunders and Curry 1990; Saunders and Ingram 1995). Even large remnants are unable to retain the full complement of the native avifauna (Saunders 1989). For example, East Yorkrakine Reserve (81 ha) has lost three species since the 1970s, while Durokoppin (1 100 ha) has lost 10 species since the 1940s (Saunders 1989). Lambeck (1995) concluded that the nature reserves in the wheatbelt were inadequate by themselves for the conservation of the region's honeyeaters. As elsewhere, honeyeaters rely on a temporal and spatial sequence of nectar and insects that is not entirely provided within the reserve system.

Cale (1993) analysed 76 species of terrestrial birds in the Kellerberrin District in the central wheatbelt of Western Australia. He concluded that 25 species (33%) were locally extinct (15 species, 20%) or had declined in abundance (10 species, 13%) in the district. Based on habitat loss, and by adding 33 species Cale describes as dependent on remnant vegetation to the 25 he recognizes as having declined, I conclude that 58 of the 76 species (76%) have declined in abundance in the Kellerberrin District compared with a clearing rate of 93%. Species which have declined in the central portions of the wheatbelt remain abundant further east and along the wheatbelt's western margin where clearing has been less extensive (Saunders and Ingram 1995, pers. obs.).

Perth, Western Australia

Recher and Serventy (1991) and Recher (1997a) compared changes in the abundance of birds in Kings Park, Perth between the 1920s and 1995. Of 44 species recorded between 1927 and 1986, 16 (36%) decreased in abundance (10 to local extinction), 14 (32%) showed no change, while 14 (32%) increased in abundance (Recher 1997a). Since 1986, these trends have continued and an extensive wildfire in 1989 resulted in 11 of 29 species (38%) that were recorded regularly within the park in 1986 declining in abundance through 1998 (Recher 1997a; Recher, unpubl. data). Despite its size (400 ha), the increasing isolation of the park through urban expansion and the decline of the avifauna in surrounding districts has prevented recolonization and contributes to the decline in abundance of non-resident species formerly occurring in the park.

Declines in the avifauna of Perth are not restricted to Kings Park. How and Dell (1993) described the changes in the abundance of birds within the Perth Metropolitan Region since the establishment of the Swan River Colony (Perth) in 1829. Of 176 species recorded for the Metropolitan Region, six have become locally extinct, 73 others have declined, while 18 have become more abundant. Thus, 55% of the avifauna in the Perth Region has experienced significant changes in abundance with declines in abundance and local extinction occurring before Serventy commenced his counts in Kings Park in 1927 (Recher 1997a). "Nearly all" insect-eating and nectar-feeding birds have declined since European settlement as a result of habitat loss, while declines among non-passerines have affected all trophic levels (How and Dell 1993). The avifauna of Perth has also been affected adversely by declines in abundance of birds in surrounding districts as a consequence of development, clearing, logging and changed fire regimes (Recher 1997a).

Mt Lofty Ranges, Adelaide, South Australia

Ford and Howe (1980) described the status of the avifauna in the Mt Lofty Ranges of South Australia. Of 116 species originally present, only 90 were recorded in 1977. The losses were attributed to the clearing and fragmentation of the original forest (Ford and Howe 1980). In 120 years of European settlement of South Australia, 90% of the forest in the Mt Lofty Ranges was cleared. The largest remnants in 1977 were patches of a few thousand hectares which contrasted with the original area of forest in excess of 500 000 ha. Using the relationship between the number of bird species and patch size, Ford and Howe (1980) calculated that a further 35 to 50 species (a total of 52 to 65% of the original avifauna) would be lost from the Mt Lofty Ranges compared with the clearing of 90% of the vegetation. In fact, it is reasonable to conclude that 100% of the forest dependent bird species in the Mt Lofty Ranges have declined in abundance since European settlement.

Subsequently, Paton *et al.* (1994) compared the frequency of occurrence of bird species in the Adelaide Region, including the Mt Lofty Ranges, between 1974/75 and 1984/85. Of 103 species of terrestrial birds, 25 (24%) increased in abundance over the decade, 51 (50%) showed no change, and 27 (26%) decreased; 50% of the avifauna experienced a change in abundance over the decade. Many of the increases were of honeyeaters (Meliphagidae) and parrots (Psittacidae) in the suburbs of Adelaide where plantings of native vegetation, particularly eucalypts *Eucalyptus*, have increased and matured. Species to increase included honeyeaters that appear to be declining outside the Adelaide Region (Paton, pers. comm.) and the apparent increases in abundance may be entirely local with a smaller number of individuals congregating in areas with large numbers of observers and abundant nectar.

Northern Tablelands, New South Wales

Of 137 species of birds recorded at 390 woodland sites on the Northern Tablelands of New South Wales, Barrett *et al.* (1994) found that only 33 (24%) were not adversely affected by changes associated with farming and grazing. About 50% of the original forest and woodland has been cleared on the Northern Tablelands and most of the remainder is degraded by grazing. Of 92 species considered to have been common on the Northern Tablelands prior to settlement, Barrett *et al.* (1994) concluded that 24 (26%) are endangered on the Northern Tablelands, while 35 (38%) are rare or inadequately known. Thus under conventional definitions, 59 of 92 species (64%) are threatened. However, by giving more weight to habitat loss and declines in abundance, I conclude that 76/92 species (83%) should be considered threatened on the Northern Tablelands and that only 16 species have benefited from or been unaffected by European settlement. As there are no historical data describing the avifauna of the Tablelands, even this may be an underestimate of impact of settlement.

Arid and Semi-arid Australia

Smith and Smith (1994) evaluated the status of 208 species of terrestrial birds in the arid and semi-arid regions of western New South Wales. Of these, the Smiths considered that 49 species (24%) had increased in abundance, 69 (33%) had shown no change, and 90 (43%) had declined in at least part of their distribution within the region. In fact, the number of declines are greater than suggested by the Smiths. One hundred and three species (49%) have declined in abundance in at least one vegetation type within their distribution (data from Smith and Smith 1994, Appendix A). If allowance is made for habitat loss, then at least 140 species (67%) have declined in abundance and/or distribution since European settlement of western New South Wales. Taking increases into account, virtually the entire avifauna (91%) of western New South Wales has been adversely affected by Europeans.

Reid and Fleming (1992) reviewed the status of birds in Central Australia's arid and semi-arid pastoral zone. One hundred and sixty-one species of terrestrial birds occur in the region and, of these, 12 (7%) are listed as threatened or rare nationally, while 13 (8%) are taxa of special concern (Garnett 1992). Twenty-six species (16%), that are not listed nationally, have declined in at least part of their distribution within the arid and semi-arid pastoral zone (data in Reid and Fleming 1992). Applying the criteria adopted in this paper, 51 of 161 terrestrial species (32%) in Australia's arid and semi-arid shrub- and grasslands are threatened. According to Reid and Fleming (1992), 44 species (27%), including a group of ground-foraging birds associated with degraded lands, have increased in range or abundance. This includes two of the species listed as having declined in at least part of their distribution within the region. In all, 59% of the avifauna in Central Australia has experienced a significant change in abundance since European settlement. This is probably a conservative evaluation of the changes to the avifauna. For example, observations by Recher and Davis (1997) suggest that the avifauna in mulga woodlands near Alice Springs has been significantly affected by habitat degradation as a result of overgrazing, with extensive areas of habitat largely devoid of birds bar a small number of large, ubiquitous species.

In a review of the status of birds in the Murchison District of Western Australia, Saunders and Curry (1990) found that, of 118 birds species recorded for this pastoral region, eight (7%) had gone to extinction since European settlement, 21 (18%) had increased in abundance, and no change could be determined for 89 (75%). This does not mean that 75% of the Murchinson's avifauna was unaffected, but only that there were insufficient data to determine their status. Even so, 25% of the avifauna had undergone a significant change in abundance with every likelihood that the number is much greater.

Northern Australia

Although there is a concentration of rare and endangered species in northern Australia (Woinarski and Braithwaite 1990; Garnett 1992), only limited data on the status of birds are available. Woinarski (1993) listed 23 species from tropical savannahs as being of conservation concern. He commented that grazing adversely affects bird populations and that 80% of tropical savannah lands (99% of Mitchell grasslands) are held as pastoral leases. Kikkawa (1993) considered all 208 species of rainforest birds in Queensland to be protected within existing national parks, but 50 species (24%) may need special management because of their large size, small populations, frugivorous habits, or because they were migratory.

Franklin (in press) analysed historical trends of granivores in northern Australia and concluded that there have been significant declines in more than 30% of taxa. Franklin describes this guild of birds as "a community in disarray". It seems clear that, as predicted by Recher and Lim (1990), the avifauna of northern Australia is experiencing the same range of adverse impacts from European settlement as documented for southern and central Australia.

Etcetera, etcetera

Other accounts of changes in the abundance of species and the composition of regional avifaunas have been provided for New South Wales by Heron (1973) for the Orange District on the Central Tablelands, for the Sydney Region by Hoskin *et al.* (1991) and Keast (1995), and for the Inverell District by Baldwin (1975). Jack (1973) described changes in avian numbers for the Brisbane Region in southeastern Queensland, while Masters and Milhinch (1974) commented on changes in the avifauna of the Shire of Northam east of Perth. Barnard (1925) provided an early report on the effect of agriculture and drought on Australian birds in his account of 50 years of bird observation on Coomooboolaroo Station, Duaringa District, Queensland. In all instances there were significant declines in the abundances of bird species associated with changes in the native vegetation accompanying clearing, grazing, and changed fire regimes, although these did not always occur immediately. The development of agriculture and urbanization created new habitats allowing other birds to increase in abundance or to extend their distribution.

The decline of birds in the Inverell and Orange Districts of New South Wales is typical. Six formerly common species including Jacky Winter *Microeca leucophaea*, Crested Bellbird *Oreoica gutturalis*, Bush Stone Curlew *Burhinus magnirostris*, and Hooded Robin *Melanodryas cucullata* are now uncommon or rare in the Inverell area (Baldwin 1975). The Australian Crow *Corvus orru*, has been displaced by the Australian Raven *C. coronoides*. At Orange the Emu is locally extinct and five other species described by Heron (1973) as formerly abundant are now rare. These include Hooded Robin, Spotted Quail-thrush *Cinclosoma punctatum*, and Grey-crowned Babbler *Pomatostomus temporalis*.

In the Shire of Northam, Regent Parrot *Polytelis anthopeplus*, Major Mitchell Cockatoo *Cacatua leadbeateri*, Painted Quail *Turnix vaaria*, Western Yellow Robin *Eopsaltria griseogularis*, Golden Whistler *Pachycephala pectoralis*, Western Thornbill *Acanthiza inornata*, and White-naped Honeyeater *Melithreptus lunatus* are among a large number of species to decline. Crested Pigeon *Ocyphaps lophotes*, Black-shouldered Kite *Elanus notatus* and Chestnut-rumped Thornbill *A. uropygialis* colonized the shire following clearing (Masters and Milhinch 1974). Masters and Milhinch (1974) also comment that a number of species, including Crested Bellbird and Redthroat *Sericornis brunneus*, probably occurred in the Shire before settlement by Europeans, but have never been recorded. Comments such as these probably pertain to all districts and it can be accepted that the avifauna in agricultural and pastoral areas throughout Australia began to change as soon as settlement, agriculture and land clearing commenced.

In most instances, 20th Century observers are only documenting the end of a lengthy and continuing process of decline and change (Recher 1997a). Barnard's (1925) account of the avifauna of Coomooboolaroo Station is a case in point. The station was a pastoral property of about 400 km^2 which the Barnard family acquired in 1873 (Barnard 1925). Over 50 years, Barnard documented many changes in the station's avifauna which he attributed to "chiefly" climatic influences and "to some extent" to the effects of grazing by cattle. Cattle "trampled" the long grass along creeks, silting up waterholes, affecting both waterbirds and species dependent on the grass, such as Pheasant Coucal *Centropus phasianinus* Chestnut-breasted Finch *Lonchura* (*Donacola*) *castaneothorax*, and Red-backed (Orange-backed) Wren *Malurus melanocephalus*. Severe drought in 1902 led to the decline or loss of many species, some of which had recovered by the 1920s (Barnard 1925). In all, Barnard (1925) recorded 180 species of terrestrial birds on Coomooboolaroo. Of these, 42 (23%) are identified by Barnard as having become less abundant since 1873, while 4 (2%) had increased in abundance. Besides birds of long grass, species associated with softwood scrubs were prominent among those to decrease in abundance. This was probably a result of clearing. Species which Barnard (1925) mentioned as becoming more abundant do not include those which colonized the station after the 1902 drought (e.g., Diamond Dove *Geopelia cuneata*) some of which remained in residence. During a recent and brief survey of "Coomooboolaroo" (the station is now broken up), Woinarski and Catterall (*in litt.*) recorded 150 species of birds, including water birds. They found many grassland species had recovered since Barnard's (1925) account, including Pheasant Coucal and Red-backed Wren, probably as a result of changed grazing management and the introduction of exotic grasses. Conversely, many birds of Brigalow *Acacia harpophylla* and eucalypt woodlands had declined. Included among these were thornbills (Pardalotidae), lorikeets (Pssitacidae), honeyeaters (Meliphagidae), robins (Petroicidae), flycatchers (Dicruridae) and finches (Passeridae) most of which species Barnard (1925) considered common. Woinarski and Catterall (*in litt.*) attribute these losses to the "almost complete removal of this habitat [Brigalow and eucalypt woodlands], both on this property [Coomooboolaroo] and regionally."

Near Sydney and Brisbane, the Black-eared Cuckoo *Chrysococcyx osculans* has declined in abundance along with its preferred host species, the Speckled Warbler *Chthonicola sagittata* (Jack 1973; Hoskin *et al.* 1991). Of 283 species in the Sydney Region at the time of European settlement (1788), 11 (4%) are regionally extinct and 76 (27%) have decreased in abundance and/or distribution (Hoskin *et al.* 1991 in SEAC 1996). Thirty-nine species (14%) have increased in occurrence. Recher *et al.* (1993) documented the rapid rate of change in the fauna of Sydney District during the first decades of settlement. In my experience since 1967, the decline of birds in the Sydney region is much greater than acknowledged by Hoskin *et al.* (1991) and is a continuing phenomenon with the smaller passerines (e.g., honeyeaters, finches, wrens, whistlers (Pachycephalidae), robins, and thornbills) in particular disappearing from the outer suburbs and declining in the adjoining national parks, while many larger birds (e.g., Pied Currawong *Strepera graculina*, Australian Raven) have become much more abundant.

Of 87 passerines listed by Keast (1995) in his review of change in the avifauna of Sydney between 1930 and 1994, 35 species (40%) declined in numbers and/or are locally extinct. All are species that had been formerly common in the appropriate habitat. Others, such as the Pied Currawong, increased in numbers. Yet when Keast commenced his observations, the avifauna of Sydney was already greatly changed. Some formerly common species (Keast 1995), such as Jacky Winter, are birds of open woodlands and their occurrence in the northern suburbs of Sydney where Keast grew up was probably an artefact of logging and clearing. Originally the northern suburbs were heavily forested (Recher *et al.* 1993). Since the 1930s, these districts have become more densely populated, but are also now more heavily vegetated and wooded reflecting changing community standards and a decline in agriculture in the district. Thus, the decline of Jacky Winter may simply reflect changing habitat conditions as the land becomes more densely forested, just as its decline outside of the Sydney area has probably been hastened by too extensive clearing and habitat degradation. Other formerly common birds, such as the Superb Blue Wren *Malurus cyaneus*, are simultaneously victims of increased urbanization and the proliferation of nest predators such as the Pied Currawong and Australian Raven (Major *et al.* 1996).

Status of honeyeaters

The impact of European settlement on Australian birds is not restricted to local or regional avifaunas and resident species. There is growing evidence that migratory and nomadic species are declining throughout their distribution. This is illustrated by the honeyeaters, a speciose, abundant and widely distributed group of birds throughout Australia almost all of which are nomadic or migratory to some degree (Keast 1968, pers. obs.).

From discussions with biologists throughout Australia, as well as my own observations in New South Wales and Western Australia since 1967, I have reached the conclusion that there has been a continental decline in the abundance of honeyeaters. I first noted this decline in honeyeaters during work in southeastern New South Wales in the mid-1970s. The losses are especially noticeable where honeyeaters congregate on nectar-rich flowers outside the breeding season, such as on heathlands near Sydney in winter (pers. obs., unpubl. data). There is still an abundance of nectar, but many fewer birds (hundreds instead of thousands) This was also the situation in southeastern New South Wales in the 1970s where extensive areas of nectar-rich blossom were unused by nectar-feeders.

In contrast to Adelaide (Paton *et al.* 1994), 10 of the 20 species of honeyeaters listed by Keast (1995) are less abundant than formerly and no species has increased in numbers. Species, such as Red Wattlebird *Anthochaera carunculata,* which were abundant in suburban Sydney gardens as recently as the 1970s are now rare (pers. obs.). At first the decline of honeyeaters makes little sense given the large areas of coastal lands reserved in national parks, until it is realized that honeyeaters move seasonally between habitats over a wide area of eastern Australia. It does not matter how abundant nectar may be in any one place, the numbers of nectar-feeders will be determined by the amount of nectar in the least abundant habitat. The honeyeaters visiting coastal national parks, such as near Sydney, in winter depend on forests and woodlands further inland for seasonal food sources and as nesting habitat. These forests and woodlands have been extensively cleared for agriculture, with significant clearing since the 1960s (Glanzig 1995; Graetz *et al.* 1995). John Woinarski (*in litt.*) suggests that similar declines have occurred among lorikeets (Psittacidae) and Swift Parrot *Lathamus discolor* which are also nectar-dependent species. Purple-crowned Lorikeet *Glossopsitta porphyrocephala* has greatly decreased in abundance throughout its range in southern Australia (e.g., Masters and Milhinch 1974; Smith and Smith 1994; Saunders and Ingram 1995).

There are also the first warning signs that many migratory insectivorous species in southeastern Australia, such as the Rufous Whistler *Pachycephala rufiventris* and White-throated Warbler *Gerygone olivacea,* which winter in Queensland, have been affected by the extensive clearing that has taken place in that State since the 1980s. For example, 90% of the Brigalow *Acacia harpophylla* woodlands and the associated shrub communities in Queensland have been cleared (Cummings *et al.* 1993) and both the whistler and warbler which may have wintered in the Brigalow appear to have declined during the 1980s and 1990s (pers. obs.). Regrettably, as in the case of the effects of land clearing in Central and South America on migratory birds from North America (Hagan and Johnston 1992; Sauer *et al.* 1996), data are lacking and the relation between land clearing in Queensland and the decline of migratory species in eastern Australia cannot be proven.

Increases in abundance

Like extinction, changes in the distribution and abundance of birds are normal ecological events which typically occur in response to long-term, gradual changes in climate independent of the activities of other species. Also like modern extinction rates (see Smith *et al.* 1993; Crosby *et al.* 1994), the high rate and extent of change in the Australian avifauna since European settlement is abnormal and a consequence of human activities. Changes to the Australian avifauna include increases in abundance and/or distribution as well as declines: both are dysfunctional. Increases in abundance adversely affect ecological processes and ecosystem function and are as much an indicator of ecosystem dysfunction and instability as are the decline and extinction of populations and species. Taken together, the number of increases and decreases in the distribution and abundance of birds provides a better measure of the impact of European settlement on the Australian continent than either does alone.

Throughout southern Australia there have been significant increases in the abundance and distribution of several species. These are species that have benefited from an increase in habitat and food resources and/or a relaxation in competitive and predatory pressures as a result of European settlement. Some, such as the Rainbow Lorikeet *Trichoglossus haematodus* and Laughing Kookaburra *Dacelo novaeguienae* in Western Australia and the Indian Myna *Acridotheres tristis* and Starling *Sturnus vulgaris* in eastern Australia are introductions, but most have either colonized new regions on their own or were indigenous. In many cases, they are species of arid or semi-arid riverine plains (Masters and Milhinch 1974; Saunders and Ingram 1995). Agriculture and urbanization create grasslands and open parklands with an abundance of food which provide ideal habitat for these species. The majority of species to increase in abundance are seed-eaters or birds, such as the Pied Currawong, which are frugivorous outside the breeding season. These increases adversely affect other species.

For example, in southeastern Australia, the Pied Currawong has become a major predator and nest predator on smaller birds in urban and semi-rural environments (Major *et al.* 1996). The increased abundance throughout southern Australia of the Galah *Cacatua roseicapilla* has adversely affected other large parrots that it competes with for nest hollows and also by ringbarking trees in which it nests (Saunders and Ingram 1995). In eastern and southeastern Australia, Noisy Miners *Manorina melanocephala* dominate remnant woodlands and aggressively exclude smaller birds that might otherwise persist (Grey *et al.* 1996, 1998). Along the Swan Coastal Plain of Western Australia, the Australian Raven may have a similar impact to the Pied Currawong in the east (Stewart 1997, pers. obs.).

One species to increase significantly in abundance, the Port Lincoln Parrot *Barnardius zonarius*, damages and kills grasstrees *Xanthorrhoea* spp. in southwestern Western Australia by repeatedly clipping the green leaves. In some districts, almost all grasstrees are affected with a high proportion of deaths (Wendy Porter, unpubl. data). The parrot may be doing this to obtain moisture, but *Xanthorrhoea* is an important source of nectar for honeyeaters and other birds, including the large cockatoos and ravens (pers. obs.), and provides nest sites for Western Thornbill *Acanthiza inornata* (Serventy and Whittell 1967, pers obs.). The loss of *Xanthorrhoea*, although regional in extent, indicates the extent which changed abundances in birds can adversely affect ecological processes as well as other species.

DISCUSSION

The pattern that emerges from the review of the status of state, regional and local avifaunas across the Australian continent is one of the widespread change as a consequence of European settlement. Entire avifaunas are threatened: there is no account in the literature which describes an avifauna without significant numbers of species in decline while others have greatly increased in numbers. Those species which have not benefited from European settlement and increased in number, but have not gone to local extinction, are restricted to remnants of their original habitat. Mostly, habitat remnants are degraded by grazing, logging and tree death, changed fire regimes, introduced plants and animals, and loss of soil structure with consequential changes in the soil and litter biota, and the ground and shrub vegetation layers.

As a result, throughout Australia, the birds most affected are those that nest, live or feed on the ground or in the shrub layer, those that require tree hollows for shelter and nesting, seed-eaters, migrants within Australia, and nectar-feeders (Recher and Lim 1990; Garnett 1992; Saunders and Ingram 1995; Lunney *et al.* 1997). There is no one reason why all these groups have been affected, but it is obvious that, if half of the land in Australia is degraded as suggested by evidence in SEAC (1996) and remnant vegetation is as affected as even casual observation quickly confirms, birds that depend on ground and shrub vegetation, and the soil litter for nesting, cover and food will also be affected. These are also the birds that are most likely to be affected by introduced predators. The survivors in agricultural areas are mainly canopy foragers and nesters, but even these will disappear as mature trees progressively die and disappear from the landscape. The rate of change has been and is rapid: there were significant changes in the distribution and abundance of birds before they could be documented (but see Barnard 1925; Serventy 1938). Although much of the data are anecdotal and cover relatively short periods of time, the patterns are the same.

Depending on the extent of clearing and habitat degradation, 30 to 90% of Australian terrestrial bird species have declined in abundance and distribution. Another 10–30% of species at each location have increased in abundance. Taken together, the impact is pervasive and almost certainly has adverse effects on ecological functions and processes, although these remain to be documented. With continued clearing of native vegetation, changed fire regimes, and accelerating land degradation in agricultural, forestry and pastoral zones, the prognosis for the avifauna as a whole is not good.

I expect less than half of Australia's terrestrial bird species will survive the next one hundred years. If I am wrong, it will only be because birds are tenacious and the rate of extinction will be slower than I anticipate, or because Australians modify their behaviour and change the ways they manage and exploit the continent's lands, waters and natural resources. However, at the close of the 20th Century, there is no evidence that this will happen and all trends are towards a continued, rapid decline in the avifauna with the progressive loss of regional populations culminating in continent wide extinctions. If the loss of species is not as great as I predict, Australia will still lose most of its avian biodiversity through the decline and extinction of populations and massive change in the species composition of bird communities. The great majority of birds will be diminished, while a few will continue to be extraordinarily abundant. The conspicuousness of these few, superabundant commensals of humanity will mean that few Australians will notice the losses (Recher 1996/97). My analysis and prediction is not novel: they are simply a description of events as they have happened over the past 200 years.

While the impact of European settlement on the avifauna has been greatest in southern and coastal Australia, the pattern of change is being repeated in northern Australia and the Centre. With continued growth, the impact of development on the northern avifauna and that of the arid pastoral zones will converge on those of the southern avifauna. It is only the lack of historical records for these regions that prevents us from describing the changes that have already occurred. It is important to remember that the extinction of a species is only the final act in a long process of decline and loss; long before the last individual dies, a population or species is "ecologically extinct". Over much of Australia, many species are already ecologically extinct.

If my evaluation of the status of the Australian avifauna and prognosis for the future appears unrealistic, I have company. Assuming that current rates of endangerment continued, Smith *et al.* (1993) predicted that half of the world's 9 500 species of birds will become extinct within the next 200 to 300 years. Using a more comprehensive set of data, Crosby *et al.* (1994) predicted that "between 400 and 1 200 species of birds may become extinct within the next 100 years." According to their models, the half-life for the world's avifauna lays between 800 and 2 800 years depending on the constancy of threatening processes and rates of habitat loss. Exactly the same situation pertains to Australia.

Is it possible to reverse these trends?

Different perceptions of status

A first step is to review the way we identify and list threatened biota. Since 1980, successive lists of threatened Australian birds have increased the number of listed species. However, in contrast to my estimates of 30 to 90% of the terrestrial avifauna, Garnett's (1992) account of the status of Australian birds listed only 17% of taxa as threatened or species of special concern, a value now being increased by nearly 1.5% (see Garnett 1999). Using the 1996 IUCN Red List of Threatened Animals, Stattersfield (1998) ranked Australia ninth among nations in the Southern Hemisphere for the number of threatened birds: 6% of the Australian avifauna or 44 of 680 species. Compared to the massive changes in abundance and distribution affecting almost all terrestrial birds evident in regional studies, even with the most recent revisions (Garnett 1999) these percentages are much lower than my estimates for the following reasons:

1. "Official lists", such as Garnett's, are constrained by government policy and by the emphasis on species or distinct taxa. This is not a criticism of Garnett (1992). Instead, it illustrates the difficulty in assessing the status of animals which have a wide distribution and may remain abundant over part or even over most of their range. It also highlights the inherent flaw in basing status on the species and not on the species' populations.

   To properly assess the status of birds in Australia, I believe it is necessary to use trends in abundance shown in regional studies. It is also necessary to assume that the same threatening processes will continue to operate and perhaps to increase in scale and intensity. A taxon which is abundant in part of its distribution, but declining or extinct elsewhere is, in my opinion, threatened. When entire regional avifaunas, comprised of many of the same species, are in decline, it is powerful evidence that most of the component taxa are at risk of cumulative extinction across the continent.

   The same argument can be made for guilds of birds (e.g., ground nesters) which have declined in some regions, but perhaps not in others. Almost certainly such guilds are particularly sensitive to environmental change and degradation, while the differences between regions are the result of different historical patterns of development. These guilds will decline progressively from region to region as development and habitat alteration proceeds and this needs to be incorporated in the listing process.

2. Official lists rarely consider species which have benefited from European settlement and increased in numbers and distribution. These changes, while not necessarily threatening the species concerned, indicate disruption of the avifauna as a whole. When added to the number of taxa in decline, these increases suggest that a much larger proportion of the avifauna is threatened than listed officially. They are also evidence of the loss of biodiversity in the form of changed communities of birds,

but as yet, there are no lists of threatened or extinct animal communities. This should be a priority for action.

3. Absolute abundances and extent of distribution are given more weight in official lists than the loss of individuals associated with land clearing, habitat fragmentation and habitat degradation. This is true even for the most recent IUCN criteria (see Collar *et al.* 1994; Stattersfield 1998), which consider rapid declines (e.g., more than 50% over 10 years or three generations) as grounds for listing. There needs to be a category which weights the percentage loss of habitat in absolute terms. Taxa which have lost 50 to 90% of their habitat since settlement are, in my opinion, highly threatened regionally and endangered nationally as regional populations become extinct. I am encouraged by Garnett's (1999) advice that approaches similar to this have already been adopted for marsupials and are being considered for birds.
4. Official assessments of status, whether on a continental or regional scale, have been unable to project the effects of threatening processes into the future. Instead, they assess status on the basis of historical events (e.g., rapid decline, size of range). The system is reactive, rather than proactive. As a result, they have been unable to anticipate cumulative losses of populations which would result in a change in status of species from "not threatened" to "threatened". This is particularly difficult to correct as it requires recognition that some very abundant species with what appear to be stable populations are at risk. Such is the case for canopy dependent birds within the agricultural regions of southern and eastern Australia where the progressive loss of mature trees will inevitably lead to precipitous declines in abundance. Although it may be politically difficult to achieve, procedures need to be in place which both allow abundant species to be listed and give recognition to local and regional threats independent of continental status.
5. An "unfavourable population viability analysis" is one of the criteria used to determine species' status by the IUCN (Collar *et al.* 1994; Stattersfield 1998). PVA is a tool which allows the interaction of trends, habitat change and life history characteristics and, as such, enables predictions to made on the future viability of species. Unfortunately, PVA requires an amount of information on individual species that is unlikely to be available for more than 90% of the Australian avifauna in the foreseeable future (see Lunney *et al.* 1996, 1997). To avoid listing species as "not threatened" when in fact their long-term viability is compromised, assessments of status must rely on expert opinion and interpretation of qualitative, as well as quantitative, data. This is what I have attempted to do in assessing the overall status of the Australian avifauna in this paper. A model for Australia is the approach taken in New South Wales by Lunney and his colleagues (see Lunney *et al.* 1996, 1997).

Sustainability

We should view the decline of Australia's avifauna as a symptom of more serious problems and seek to remedy them by correcting the underlying causes and not by treating symptoms. Australia has approached the conservation of native wildlife species by species. It has responded to events and public concern with rules and regulations and the creation of parks and reserves. If Australia is to conserve its terrestrial avifauna, it must take a different approach. Emphasis needs to shift from species preservation to the management of ecosystems; the landscape must be managed in its entirety. Land management and the conservation of wildlife must be extended to include all lands irrespective of tenure. This can only be achieved by the full co-operation of land managers, land owners and politicians alike, working towards specified national objectives: Australians need to question the sustainability of their demands on the continent. The decline of the avifauna is evidence that these demands are not sustainable.

In opening his review of the extinct and threatened birds of Australia, Garnett (1992) referred to "sustainable development and the conservation of biodiversity" as two concepts that had captured our imagination. He went on to say that the loss of "genetic diversity . . . is a sign that our activities are not sustainable", but that if "taxa with small populations" persist or increase in abundance, "it is an indication of environmental health". I agree with Garnett. The conservation of biodiversity is in no small measure the standard by which our success as a nation in achieving sustainable development can be measured. If we fail to conserve the biological richness of Australia and we lose half our birds as I expect, then our future as a free nation is limited and our lives diminished. We will have failed in the most basic of human aspirations — providing for our children a future that we would enjoy.

Contrary to the interpretation put on my views by Garnett (1999), it is not too late, nor *is the task beyond our capacity as individuals* or as a nation. Nonetheless, reversing the decline of Australia's birds requires difficult and politically unpopular choices and significant changes in community attitudes as to what matters. Garnett (1999) is correct when he says there has been a "revolution in thinking", but I do not believe that this revolution has significantly affected government and political attitudes towards the environment and other species. I base this opinion on the vast difference between what I consider the most important actions to reverse the loss of continental biodiversity and achieve an ecologically sustainable economy and what government and industry does.

In my opinion, the most urgent actions required are to end the clearing of native vegetation and to restore functional ecosystems. As part of the recovery process, restoration and tree planting needs to emphasize native (indigenous) vegetation with the goal of restoring native vegetation to a minimum of 30% of the landscape at regional levels. This is in addition to the creation of a comprehensive, adequate and representative reserve system across the continent irrespective of land tenure. Restoring function to the land requires more than planting trees, although this is an obvious and essential part of the process. *It is also necessary to reduce grazing* pressure, control feral and native animals whose abundance threatens native species, and remove inappropriate fire regimes. Action on the land needs to be accompanied by an aggressive programme to improve water quality in fresh water habitats and restore environmental water flows. The final and most important element in a programme of this magnitude is the necessity of sharing costs across the community (Recher 1997b). Land owners cannot be held responsible for past social and government policies that encouraged poor management practices and land clearing, but from which all Australians benefited economically. We all benefit and we should all pay, but with minor exceptions no government in Australia has shown the environmental wisdom and political courage to move in the directions I have outlined. In the absence of such action, I repeat my prediction that Australia will lose half of its terrestrial bird species in the next century.

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